

Advanced Projects in Exoplanets

The RM Effect

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Transiting Exoplanets

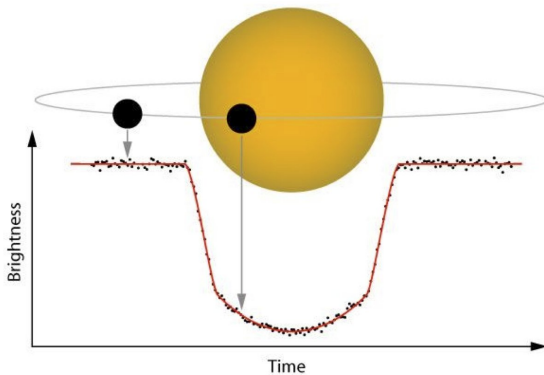


Figure: *Credit ESO*

Rossiter-McLaughlin Effect

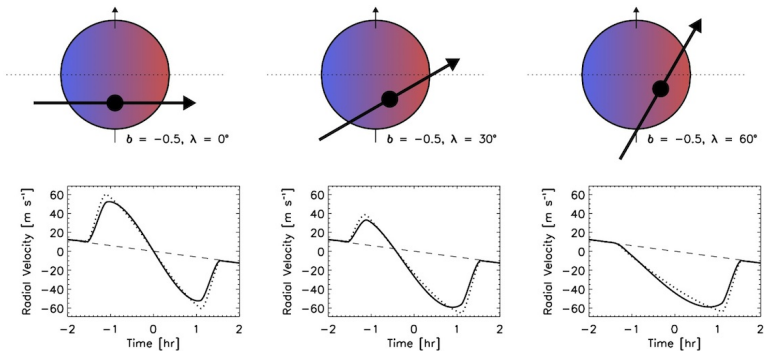


Figure:

<https://wasp-planets.net/tag/rossiter-mclaughlin-effect/>

Our Model - Linear

Planet moves in straight line in front of the star

This path is determined by:

- Projected obliquity
- Impact parameter

This model is not physical

Keplers Equations

To get $r(t)$:

Calculate mean anomaly:

$$M(t) = \sqrt{\frac{G(M_{\star} + M_p)}{a^3}} \cdot (t - t_p).$$

Calculate eccentric anomaly by numerical iteration:

$$E_{n+1} = E_n - \frac{E_n - e \sin(E_n) - M(t)}{1 - e \sin(E - n)}.$$

Calculate true anomaly:

$$\nu(t) = 2 \tan^{-1} \left(\left(\frac{1+e}{1-e} \right)^{1/2} \tan(E(t)/2) \right).$$

Calculate separation:

$$r(t) = a \frac{1 - e^2}{1 + e \cos(\nu(t))}.$$

Our Model - Physical version

Planet orbits the star.

Keplers equation is solved for input parameters.

The path is determined by:

a , e , i , ω , M_{\star} , M_p , t_p , λ , R_p/R_{\star}
and $v \sin(i_{\star})$.

Much more resource heavy, but
also correct

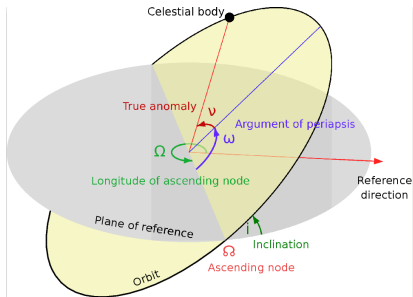


Figure: Credit: Wikipedia user Lassuncty

Modelling Planet Orbit

Calculate projected coordinates of the planet:

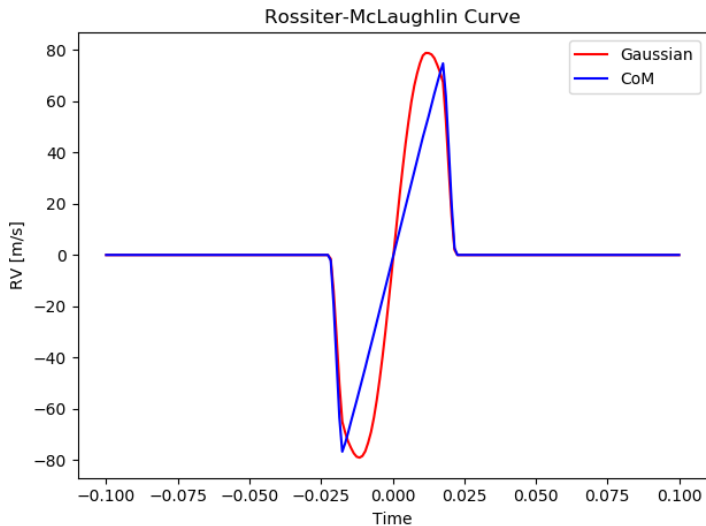
$$\begin{aligned}X_i &= -r \cos(\omega + \nu), \\Y_i &= -r \sin(\omega + \nu) \cos(i).\end{aligned}$$

$$\begin{aligned}X &= X_i \cos(\lambda) + Y_i \sin(\lambda), \\Y &= -X_i \sin(\lambda) + Y_i \cos(\lambda), \\Z &= r \sin(\omega + \nu) \sin(i).\end{aligned}$$

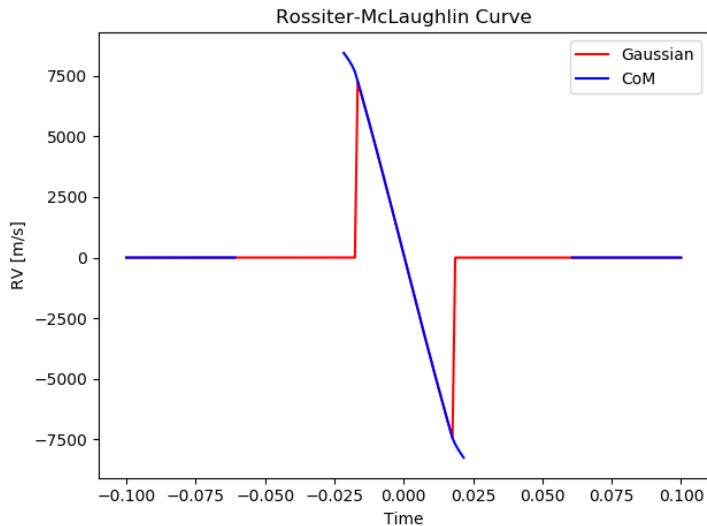
Our Model - Outputs

[Video here]

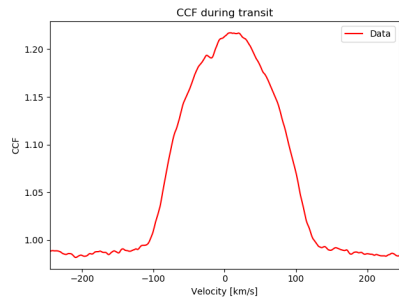
Our Model - Outputs



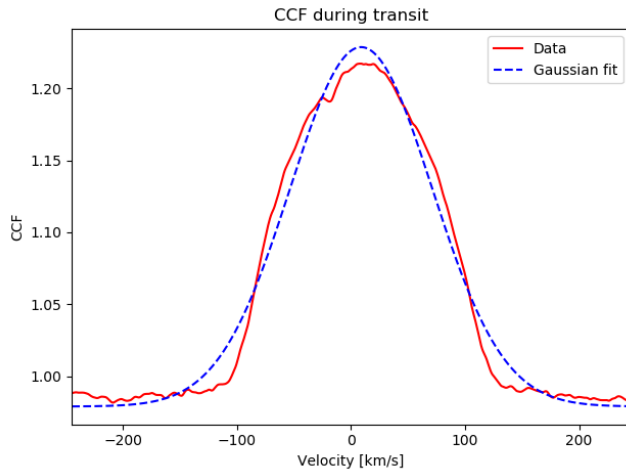
Our Model - Outputs



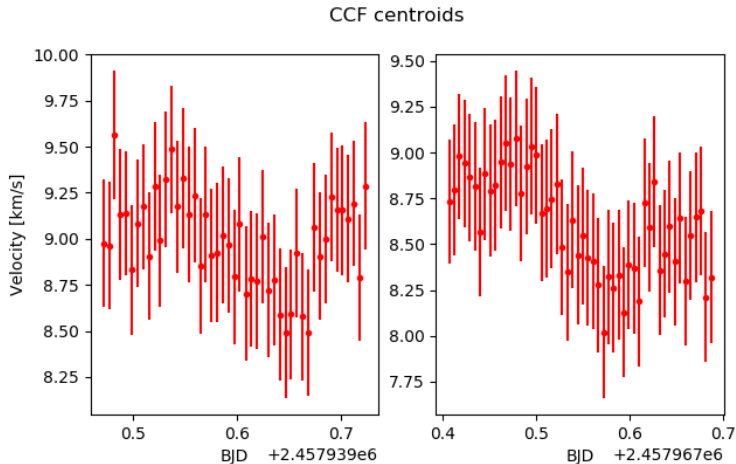
Data



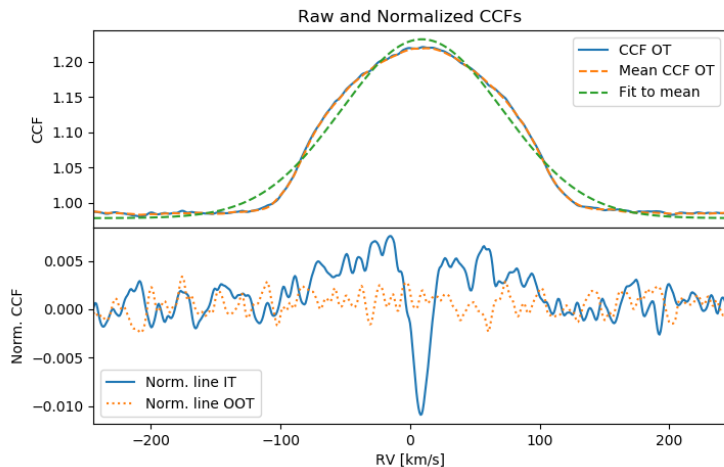
Data - The stellar line



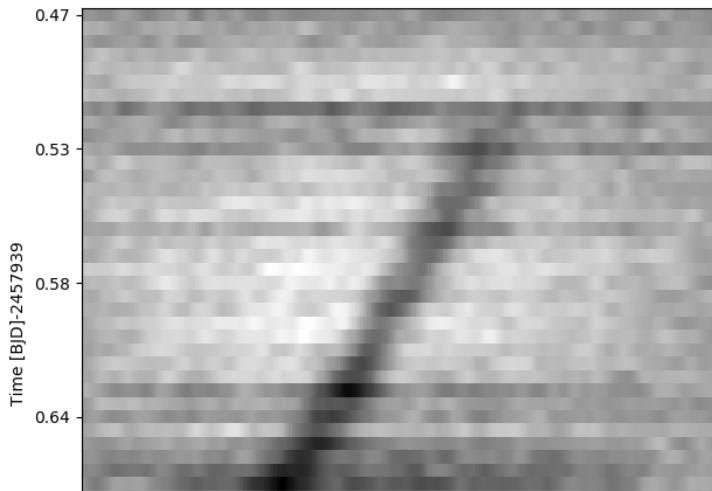
Data - The Transit



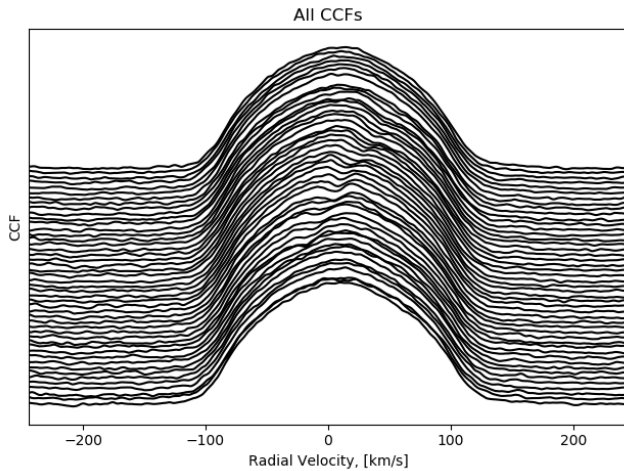
Data - The 'Planet Line'



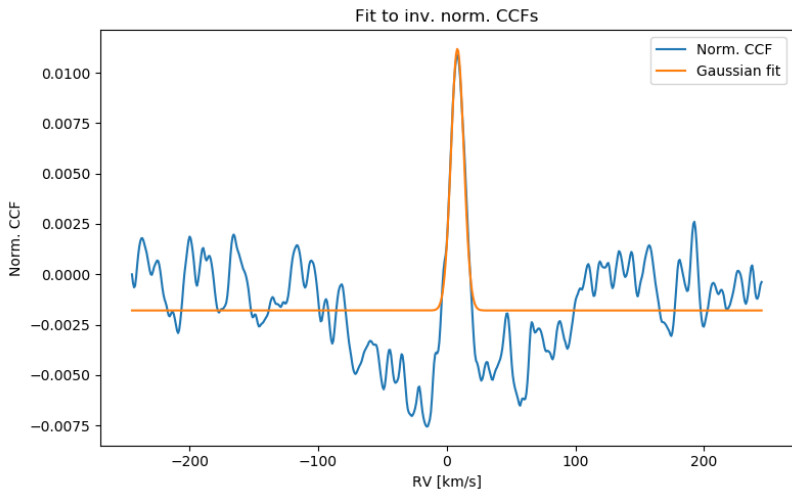
Data - The RM-effect



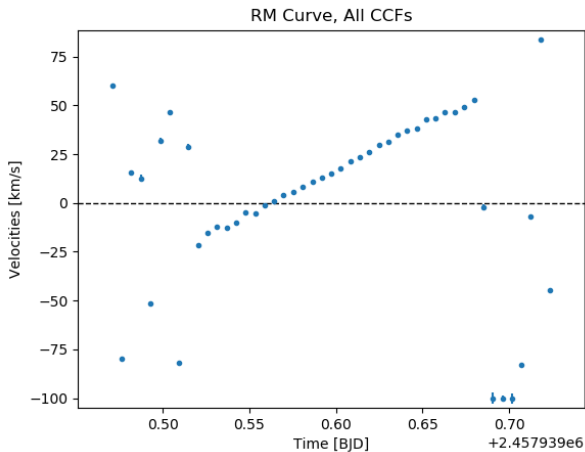
Data



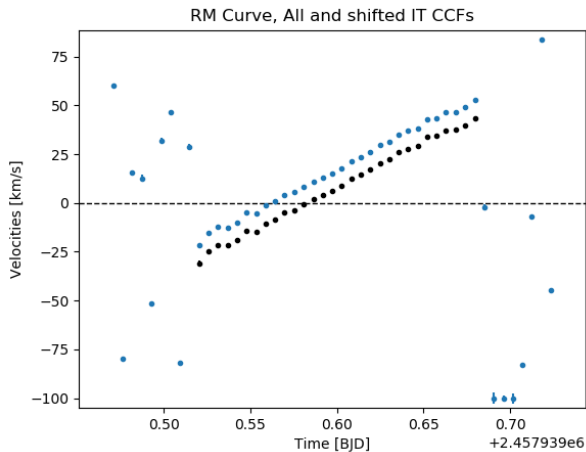
Data - Fit to CCF



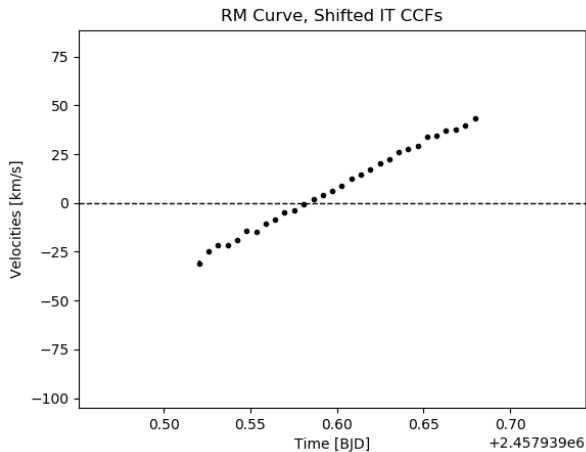
Data - RM curve



Data - RM curve



Data - RM curve



The Fit - System Parameters

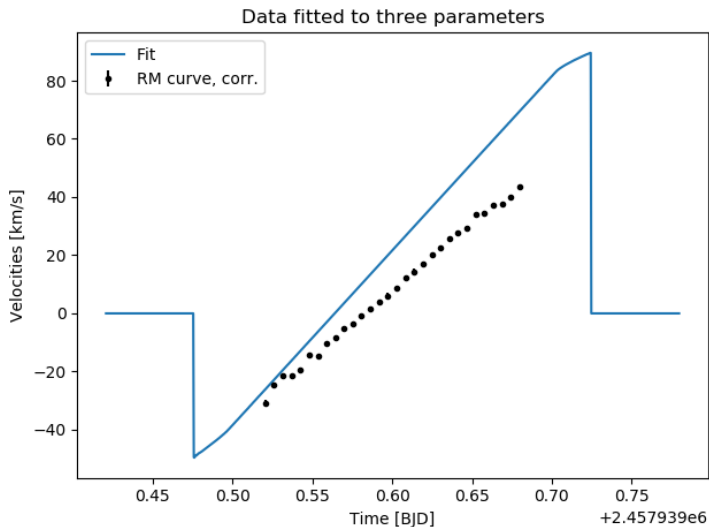
Variables:

- λ
- ω
- $v \sin(i_\star)$

Constants:

- $t_p = 0$
- $a = 4.756 R_\star$
- $e = 0$
- $M_\star = 1.72 M_\odot$
- $M_p = 3.7 M_J$
- $\frac{R_p}{R_\star} = 0.0735$
- $\omega = 90^\circ$

Fitting with curvefit



Linear fit